SOV/24-59-2-7/30

The Determination of the Temperature Field of a Gas Turbine Cooling Vane

as Eq (1.4) for free convection and as Eq (1.5) for the turbulent type of cooling (Ref 4). If Eq (1.4) or Eq (1.5) is substituted in Eq (1.3), then the formula (1.6) is obtained, which defines the problem for the conditions (1.7) and (1.8) (ξ - relative length of the shaft $\varepsilon^{4} \approx 10^{-4}$). This formula cannot be easily integrated, therefore its approximate solution is preferable. This can be based on Eq (2.1) and on the following theorems.

Theorem 1. If the following exist:

(1) The function $\varphi(\xi)$ so that:

$$\phi(\xi, \varphi(\xi)) = 0 \quad ,$$

(2) The function $\phi(\xi, \Theta)$ so that:

$$0 \leqslant \xi \leqslant 1 \ , \quad \alpha_1(\xi) \leqslant \Theta - \varphi(\xi) \leqslant \alpha_2(\xi)$$ and the

Card 2/6

SOV/24-59-2-7/30

The Determination of the Temperature Field of a Gas Turbine Cooling Vane

continuous function $\alpha_1(\xi)$ and $\alpha_2(\xi)$ with the conditions:

$$\alpha_1(\xi) < 0 < \alpha_2(\xi)$$

$$\varphi(0) + \alpha_1(0) < 0 < \varphi(0) + \alpha_2(0)$$

$$\varphi(1) + \alpha_1(1) < 0 < \varphi(1) + \alpha_2(1) \quad ,$$

(3) A positive continuous function $f(\xi)$ differentiated twice,
(4) A function $\phi_\theta(\xi, \theta) \geqslant m > 0$, then for the small $\varepsilon > 0$, a solution $\Theta_\varepsilon(\xi)$ of Eq (2.1) exists which diverges to $\varphi(\xi)$ for $\varepsilon \to 0$ in the interval $[\delta, 1 - \delta]$, where $0 < \delta < 1/2$. Also, if $\varphi(\xi)$ can be differentiated twice, then Eq (2.2) can be defined for the conditions (2.3) and (2.4).

Card 3/6 Theorem 2. For the conditions (1) - (4) of Theorem 1 and

SOV/24-59-2-7/30

The Determination of the Temperature Field of a Gas Turbine Cooling Vane

for the continuous function $\varphi'(\xi)$, a solution of Eq (2.1) exists which can be verified from Eq (2.5), where p and r are determined from Eqs (2.3) and (2.4) and μ from Eq (2.6). Both theorems can be applied for finding an approximate solution. In this case the function $\phi(\xi, 0) = 0$ is equivalent to Eq (2.7) where $w(\xi)$ is obtained from Eq (2.8). The Eq (2.7) has a simple solution for any value of the function $w(\xi)$ which can be seen in the figure on p 47. As an example, the data at the foot of p 47 are given for the jet-type of cooled gas turbine. The value of α_i is determined from Eq (3.1), where

$$\lambda_{ox} = 0.464 \frac{\text{kcal}}{\text{m chas } C^{c}}, \quad \text{and} \quad \beta = 0.00292 \frac{1}{C^{o}}$$

corresponding to the angular rotation 10^4 rpm and $r = 27$ cm.

Card 4/6

The Determination of the Temperature Field of a Gas Turbine Cooling Vane

The limiting conditions are assumed as

$$\theta(0) = 0 \ , \quad \frac{d\theta(1)}{d\xi} = 0 \quad .$$

Then the approximate solution will be found from Eq (2.7) with $w(\xi)$ in this case being equal to 415×10^{-4} . From the graph of $\nu = 1/3$, the values of t and T are found as $t = 0.086$, $T = 378°C$. The value of $|t\ (0) - \theta_0 1| = 0.086$ is found from Eq (3.2), which shows that the error of approximation is of an order of

SOV/24-59-2-7/30

The Determination of the Temperature Field of a Gas Turbine Cooling Vane

ξ = ($\xi \sim \varepsilon$ = 10^{-2}). There is 1 figure and there are 5 references, of which 4 are Soviet and 1 English.

SUBMITTED: July 4, 1958.

Card 6/6

SOV/179-59-2-16/40

AUTHOR: Tirskiy, G. A. (Moscow)

TITLE: Torsion of a Hollow Rod Bounded by Zhukovskiy-Chaplygin Profiles (Krucheniye pologo sterzhnya, ogranichennogo krylovymi profilyami Zhukovskogo-Chaplygina)

PERIODICAL: Izvestiya Akademii nauk SSSR OTN, Mekhanika i mashinostroyeniye, 1959, Nr 2, pp 114-121 (USSR)

ABSTRACT: The Zhukovskiy-Chaplygin profiles are transformed conformally on to a concentric ring, and the complex variable methods of Muskhelishvili (Ref 1) are used to obtain equations for the torsional rigidity (expressed as polar moment of inertia), and the tangential stress components. The equations are in series form, and estimates are given of the accuracy obtained by taking a limited number of terms in the series. There are 1 figure and 3 Soviet references.

SUBMITTED: March 29, 1957.

Card 1/1

S/124/61/000/011/022/046
D237/D305

AUTHOR: Tirskiy, G.A.

TITLE: An exact solution for heat exchange through a disc rotating in a viscous incompressible fluid

PERIODICAL: Referativnyy zhurnal, Mekhanika, no. 11, 1961, 87, abstract 11B581 (Tr. Mosk. fiz.-tekhn. in-ta, 1959, no. 3, 85 - 92)

TEXT: An exact solution is obtained for a temperature field and for heat exchange through a disc, when different viscous incompressible fluids with different temperatures at some distance from the disc, occur on both sides of a rotating disc of infinite radius. Solutions of conductivity equations inside the disc and on both its sides fulfill the conditions of stress on side surfaces of the disc. For the Prandtl number P = 1, the equations allow exact solution in quadratures. If energy dissipation is equal on both sides of the disc, the solution is simplified and for this case, the expression was obtained for a temperature field at any P. [Abstractor's note: Complete translation].

Card 1/1

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67902

AUTHOR: Tirskiy, G. A. SOV/20-129-5-7/64

TITLE: The Fusion of a Heat-conducting Wall Behind a Moving Shock Wave

PERIODICAL: Doklady Akademii nauk SSSR, 1959, Vol 129, Nr 5, pp 989-992 (USSR)

ABSTRACT: The present paper gives an exact solution of the problem of the fusion of a plane wall in consideration of heat conduction into the wall in the region behind a plane shock wave, which in a gas at rest moves with constant velocity parallel to the wall. A steady flow of the heated gas is produced on this occasion. The boundary of the body reaches melting point as soon as the shock wave passes through a given point on the boundary. Behind the shock wave the motion of a melt-film must be taken into account, which is bounded above by the contact surface between gas and melt and below by the contact surface melt - body. The laws of the motion of these two surfaces are, at first, not known and must be determined while the problem is being solved. This problem is described by the equations of the unsteady boundary layer in the gas and in the melt film, as well as by the equations of heat conduction in the solid body. These rather voluminous equations are explicitly written down. In the theory of boundary layers pressure does not change during passage

Card 1/2

67902

The Fusion of a Heat-conducting Wall Behind a Moving Shock Wave SOV/20-129-5-7/64

through the discontinuity surface. Pressure in the melt therefore will equal gas pressure as well as the pressure p_{∞} in infinity. The boundary conditions belonging to the above equations are then written down. The mathematically formulated problem permits an exact solution for the velocity profiles, for the laws of motion, and for the normal velocities of the contact discontinuity surface and the melt surface. A system of ordinary differential equations of the 12-th order with 2 unknown parameters is obtained, which can be solved only numerically. The author finally investigates a special case, in which, besides other special conditions, the melt is an incompressible liquid with constant viscosity coefficient and heat conduction coefficient. The boundary value problem thus resulting may be dealt with numerically or, by approximation, by expansion in series. There are 2 Soviet references.

PRESENTED: August 15, 1959, by L. I. Sedov, Academician

4

SUBMITTED: May 23, 1959

Card 2/2

24(8)

AUTHOR: Tirskiy, G. A. SOV/20-125-2-13/64

TITLE: Two Exact Solutions of the Nonlinear Problem of Stefan (Dva tochnykh resheniya nelineynoy zadachi Stefana)

PERIODICAL: Doklady Akademii nauk SSSR, 1959, Vol 125, Nr 2, pp 293-296 (USSR)

ABSTRACT: The Láme-Clapeyron-Stefan problem is nonlinear even in its most simple form, because some of the boundary conditions are given on a mobile boundary. The law for the motion of this boundary is, from the outset, unknown and must be determined while the problem is being solved. The problem becomes "doubly" nonlinear if the variation of the thermal parameters is taken into account as a function of temperature. Parametric nonlinearity must be taken into account when solving such problems as are connected with the melting of bodies round which considerably heated gas currents or gas currents of high velocity flow (if the temperature of deceleration is considerably higher than the temperature of the metal or of the heat protecting covering. The present report gives the exact solutions of two of such nonlinear onedimensional problems. The author first investigates the following non-

linear onedimensional problem concerning the heating of a semi-space:

$$N(\Theta)\frac{\partial\Theta}{\partial t} = \chi\frac{\partial}{\partial y}\left[L(\Theta)\frac{\partial\Theta}{\partial y}\right], \quad y > 0, \quad t > 0;$$

$$\Theta(y, 0) = 0, \ \Theta(0, t) = 1, \ \frac{\partial\Theta}{\partial y} \to 0 \text{ or } \Theta \to 0 \text{ at } y \to \infty.$$

Here it holds that $\Theta = (T - T_0)/(\overline{T}_1 - T_0)$; $\varrho(T)c(T) = \varrho c N(\Theta)$; $\lambda(T) = \lambda L(\Theta)$; $\chi = \lambda/\varrho c$ and T_0 denotes the initial temperature of the semi-space, $\overline{T}_1$ - the temperature of the boundary of the semi-space; $\varrho(T)$, $c(T)$, $\lambda(T)$ - the density, the specific heat, and the thermal conductivity of the body, which are considered to be known functions of temperature, χ - a parameter with the dimensions of temperature conductivity. First, a case is dealt with in which the boundary value problem may be solved in closed form. On the basis of this exact solution various approximated solution methods may then be developed for any $L(f)$ and $N(f)$. The boundary value problem under investigation is equivalent to a nonlinear integral equation of the Volterra type, which may be solved by employ-

SOV/20-125-2-13/64

Two Exact Solutions of the Nonlinear Problem of Stefan

ing the method of successive approximations. The solution given here holds for $\overline{T}_1 < T_{pl}$, where T_{pl} denotes the melting temperature of the body. In the case of $\overline{T}_1 > T_{melt}$ a melting wave penetrates into the interior of the body. The law for the motion of this wave is, at the outset, not known and must be determined in the course of solving the problem. A rather voluminous solution of the problem is also explicitly written down. In the general case of variable coefficients, the boundary value problem is equivalent to a system of two nonlinear integral equations of the Volterra type. The author then investigates exact solutions of the Lamé-Clapeyron-Stefan problem of the type of uniformly propagating waves. In the case of constant thermal parameters, the solution can be found in explicit form; it corresponds to an exponential distribution of the initial temperature in the body. It is further possible to determine some exact explicit solutions for special forms of the functions $L(\varphi)$ and $N(\varphi)$. There are 6 references 4 of which are Soviet.

Card 3/4

SOV/20-125-2-13/64

Two Exact Solutions of the Nonlinear Problem of Stefan

PRESENTED: December 10, 1958, by L. I. Sedov, Academician

SUBMITTED: December 2, 1958

Card 4/4

66408

10.2000

SOV/20-128-6-12/63

AUTHOR: Tirskiy, G. A.

TITLE: Heating of a Thermal-conductive Wall Behind a Moving Compression Shock

PERIODICAL: Doklady Akademii nauk SSSR, 1959, Vol 128, Nr 6, pp 1140-1143 (USSR)

ABSTRACT: The present paper gives an exact solution of the problem concerning the heating of a plane wall in the proximity behind a plane shock wave which moves in a gas at rest with a constant wall-parallel velocity. The paper by Yu. A. Dem'yanov (Ref 2) gave the solution of the problem concerning the formation of the boundary layer of a viscous compressible gas around a semi-infinite plate behind a moving shock wave. The asymptotics investigated in the neighborhood behind the shock wave is similar to the exact solution given by S. D. Nigam. Let a plane shock wave travel in a gas at rest with the constant velocity D parallel to the boundary $y = 0$ of a thermal-conductive body (which occupies the half-space $y < 0$ and possesses temperature T_∞ at infinity); u_∞, p_∞, ρ_∞, and T_∞ denote the velocity, the pressure, the density, and the temperature in the uniform gas flow behind

Card 1/3

4

66408

SOV/20-128-6-12/63

Heating of a Thermal-conductive Wall Behind a Moving Compression Shock

the shock front at an infinite distance from the body. The temperature of the half-space boundary in the neighborhood of the shock wave can then attain the melting temperature T_m of the body material. Next, the conditions are determined under which the body begins melting behind the shock front, by simultaneously solving the equations of the unsteady boundary layer (which forms in the proximity of the half-space boundary behind the shock wave) and the equations of thermal conductivity in the solid body with corresponding boundary conditions. In the neighborhood of the shock wave, in the boundary layer, the flow is dependent on two variables. The equation system to be solved for the gas and respective boundary conditions is written down. This system with respective boundary conditions is invariant with respect to the one-parametrical group of similarity transformations. Hence, also the solution must be invariant with respect to such transformations. The resulting boundary problem is explicitly written down. This problem cannot be solved by quadratures but only by numerical computations. For this purpose, it is reconducted to the corresponding system

Card 2/3

4

66408

SOV/20-128-6-12/63

Heating of a Thermal-conductive Wall Behind a Moving Compression Shock

of integral equations, namely to a system of non-linear integral equations of the Volterra type. This system of integral equations can then be solved by the method of successive approximations. The resulting solutions are explicitly written down. There are 2 references, 1 of which is Soviet.

PRESENTED: June 2, 1959, by L. I. Sedov, Academician 4

SUBMITTED: May 27, 1959

Card 3/3

TIRSKIY, G. A. (Moscow)

"On the Theory of Disintegration of solid bodies in gas flows."

report presented at the First All-Union Congress on Theoretical and Applied Mechanics, Moscow, 27 Jan - 3 Feb 1960.

S/179/60/000/03/020/039
E081/E441

AUTHOR: Tirskiy, G.A. (Moscow)

TITLE: Approximate Solutions of Some Non-Linear Problems of Heat Conduction and Liquid Filtration

PERIODICAL: Izvestiya Akademii nauk SSSR, Otdeleniye tekhnicheskikh nauk, Mekhanika i mashinostroyeniye, 1960, Nr 3, pp 132-138 (USSR)

ABSTRACT: The paper is a continuation of previous work (Ref 1). The problem of the heating of a half-space ($y \geqslant 0$), the thermal properties of which vary with temperature, is considered. The material is initially at temperature T_0; and at time $t = 0$ a temperature T^x is applied to the boundary $y = 0$. This leads to the solution of the Volterra type non-linear integral equation (1.1) in which $\rho(T)$, $c(T)$, $\lambda(T)$ are respectively the density, heat capacity and thermal conductivity and are known functions of temperature, and χ is a parameter having the dimensions of diffusivity. An approximate method of integrating the equation is proposed, based on the series expansions (1.3) and (1.4). If only one term of the series (1.4) is taken, the zero order approximation (1.6) is obtained; two terms lead

Card 1/4

S/179/60/000/03/020/039
E081/E441

Approximate Solutions of Some Non-Linear Problems of Heat Conduction and Liquid Filtration

to (1.7). In Fig 1, the accurate solution (Eq (1.11), Ref 1) is plotted as curve 2, and the approximate solution (Eq (1.14)) is plotted as curve 1 for comparison. Fig 2 gives the results of numerical solution by a method of successive approximations; curve 1 corresponds to Eq (1.15) and curve 2 to Eq (1.16). The method is applied to the boundary problem (1.17) encountered in investigating the one-dimensional unsteady filtration of soil water from a reservoir. The zero order approximation is (1.18) and the first order approximation (1.19). The solution (1.18) is plotted as curve 1 in Fig 3 and (1.19) as curve 2; the numerical solution (Ref 3) practically coincides with curve 2. If the temperature T^{x} is greater than the melting point of the body (T_{x}) then as from $t = 0$ a melted zone will be propagated into the body from the boundary $y = 0$, the motion of the dividing boundary of the melted zone being found by solving the equations (2.1) to (2.4), where the index 1 refers to melted and

Card 2/4

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S/179/60/000/03/020/039
E081/E441

Approximate Solutions of Some Non-Linear Problems of Heat Conduction and Liquid Filtration

the index 2 to the solid material; $\varkappa\rho$ is the latent heat of melting per unit volume. Eq (2.1) to (2.3) are equivalent to two non-linear Volterra type integral equations (2.5). As before, a series representation (2.7) to (2.9) is adopted; the zero order approximation is (2.10) and the first order approximation (2.12) and (2.13). In order to assess the accuracy of the approximate solution, it is compared with the exact solution given in Ref 1. It is assumed that

$$L_i(f_i) \equiv N_i(f_i) = 1 + f_i \quad (i = 1,2), \quad p = 0.8,$$

$$m = \ell = 1, \qquad \Delta = 5$$

(p, ℓ, m and Δ are defined after Eq (2.4), p 135). The exact solution is given by (2.20) where χ_2 is the thermal conductivity at $t = 0$. Taking three terms of (1.4) and (2.8), the second order approximation is (2.21) with η_0, a and b found from (2.15) to (2.17) as

Card 3/4

S/179/60/000/03/020/039
E081/E441

Approximate Solutions of Some Non-Linear Problems of Heat Conduction and Liquid Filtration

0.159, -1.209 and -0.866 respectively, leading finally to (2.22) for the second order approximations. The accurate solution (2.20) is plotted as curve 1 Fig 4 and the approximate solution (2.22) as curve 2. If $L_i(f_i) = 1 + f_i$, $N_i \equiv 1$ $(i = 1, 2)$, $p = 0.9$ $m = \ell = 1$, $\Delta = 0.5$, the zero order approximation is (2.23) and the first order approximation is (2.24). Curve 1, Fig 5 represents Eq (2.23) and curve 2 Eq (2.24). Using a method of successive approximations to solve Eq (2.5) and (2.6) numerically, the crosses Fig 5 are obtained as a second approximation. It is concluded that for rough calculations, the zero order approximation is adequate and that the errors of the first order approximation do not exceed 1 or 2%. There are 5 figures and 3 references, 2 of which are Soviet and 1 English.

SUBMITTED: December 4, 1959

Card 4/4

86693

S/180/60/000/006/003/030
E032/E314

1.2310

AUTHOR: Tirskiy, G.A. (Moscow)

TITLE: On One Case of Heating of Rods by Friction

PERIODICAL: Izvestiya Akademii nauk SSSR, Otdeleniye tekhnicheskikh nauk, Metallurgiya i toplivo, 1960, No. 6, pp. 34 - 41

TEXT: The problem is formulated as follows. Consider a solid body occupying the half-space $y \geqslant 0$ which is kept at a constant temperature T_{01}. Suppose further that at a time $t = 0$ a second half-space at an initial temperature T_{02} is applied to it with a pressure $P(t)$. The two solids have finite thermal conductivities and move in contact with each other with a relative velocity $U_0 = \omega r$. As a result of surface friction the amount of heat reaching the two bodies per unit area of contact will be $q(t) = fU_0P(t)$ where f is the dry friction coefficient. It is then assumed that

Card 1/4

86693
S/180/60/000/006/003/030
E032/E314

On One Case of Heating of Rods by Friction

$U_0 P(t) = Bt^{-1/2}$ in which case the amount of heat reaching the two bodies per second per unit area at a time t is given by

$$Q(t) = \int_0^t f\,Bt^{-1/2}dt = 2fB\sqrt{t}\ .$$

Under these conditions the problem of the determination of the condition under which one or both the contacting surfaces reach the melting point is reduced to the solution of the non-linear set of differential equations

$$N_1(\theta_1)\frac{\partial\theta_1}{\partial t} = \chi_1\frac{\partial}{\partial y}\left[L_1(\theta_1)\frac{\partial\theta_1}{\partial y}\right] \qquad (-\infty < y < 0,\ t > 0) \qquad (1.1)$$

$$N_2(\theta_2)\frac{\partial\theta_2}{\partial t} = \chi_2\frac{\partial}{\partial y}\left[L_2(\theta_2)\frac{\partial\theta_2}{\partial y}\right] \qquad (0 < y < \infty,\ t > 0)$$

Card 2/4

86693

S/180/60/000/006/003/030
E032/E314

On One Case of Heating of Rods by Friction

These are subject to the conditions

$$\theta_1(y,\ 0) = \theta_1(-\infty,\ 0) = 1, \qquad \theta_2(y,\ 0) = \theta_2(\infty, t) = 1$$

$$k\theta_1(0,\ t) = \theta_2(0,\ t), \qquad knL_1(\theta_1)\frac{\partial\theta_1}{\partial y}\bigg|_{y=0} - L(\theta_2)\frac{\partial\theta_2}{\partial y}\bigg|_{y=0} = \frac{fB}{T_{02}\lambda_2}t^{-1/2}, \quad (1.2)$$

where

где

$$\theta_i(y,\ t) = \frac{T_i(y,\ t)}{T_{0i}}, \qquad \rho_i(T_i)\,c_i(T_i) = \rho_i c_i N_i(\theta_i), \qquad \lambda_i(T_i) = \lambda_i L_i(\theta_i)$$

$$\chi_1 = \frac{\lambda_i}{\rho_i c_i} \quad (i = 1,\ 2), \qquad k = \frac{T_{01}}{T_{02}} \quad (i = 1,\ 2), \qquad n = \frac{\lambda_1}{\lambda_2}$$

and ρ_i, c_i, λ_i are the densities, specific heats and thermal conductivities of the bodies respectively ($i = 1,\ 2$).

Card 3/4

86693

S/180/60/000/006/003/030
E032/E314

On One Case of Heating of Rods by Friction

It is shown that these equations are equivalent to a system of two nonlinear integral equations of the Volterra type. The equations are solved by a power-series method and the zero-order and first-order approximations to the complete solution are obtained. The paper is concluded with the application of the above theory to the special case where a) the two bodies have equal thermal coefficients and the same temperature so that the problem is symmetrical with respect to the separation boundary; b) the fused layer is an incompressible liquid of constant viscosity and c) the motion of the fused layer is laminar. There are 2 tables and 3 Soviet references.

SUBMITTED: January 22, 1959

Card 4/4

S/020/60/132/04/14/064
B014/B007

AUTHOR: Tirskiy, G. A.

TITLE: The Surface Melting of a Semi-infinite Body in a Plane or an Axially Symmetric Flow of an Incompressible Gas

PERIODICAL: Doklady Akademii nauk SSSR, 1960, Vol. 132, No. 4, pp. 785-788

TEXT: Exact solutions of the Navier-Stokes equations and of the onflow equation are obtained, which describe the steady surface melting in the neighborhood of the critical point of a body round which the gas flows. It is assumed that the body is in a plane or axially symmetric gas flow, while rotating in the latter case with constant angular velocity. First, the plane problem is dealt with, and the author proceeds from the differential equations (1) (non-steady Navier-Stokes equations, and the equation for the onflow of the body round the melting body), the differential equations (2) (non-steady Navier-Stokes equations and the equation for the onflow of the body in the melted film), and the heat-conduction equations (3) for the solid. For these differential equations the boundary conditions are given, and proceeding from these, the

Card 1/2

The Surface Melting of a Semi-infinite Body in a Plane or an Axially Symmetric Flow of an Incompressible Gas

S/020/60/132/04/14/064
B014/B007

differential equations (11) - (15) are derived in consideration of the fact that for the steady surface melting the solution must be of the type of a uniformly propagating wave. The solution of these equations is also the solution of the differential equations (1) - (6). An analogous method is employed for the axially-symmetric problem, and the system of differential equations (22) - (28) is obtained. In conclusion, the author briefly discusses the construction of the solution of the boundary problems of the two systems of equations obtained. Generalization to compressible gases of variable viscosity and heat conductivity is possible. There are 4 Soviet references.

PRESENTED: January 20, 1960, by L. I. Sedov, Academician

SUBMITTED: December 10, 1959

B

Card 2/2

TIRSKIY, G. A., and SOVERSHONNYY, V. C.

"Sublimation of a Body Near the Critical Point in a Flat and Axi-symmetrical Gas Flows."

Report submitted for the Conference on Heat and Mass Transfer, Minsk, BSSR, 5-9 June 1961.

SOVERSHENNYY, V.D.; TIRSKIY, G.A.

[Sublimation of a solid near the critical point in plane and axially symmetric gas flows; Conference on Heat and Mass Transfer, Minsk, January 23-27, 1961] Sublimatsiia tverdogo tela v okrestnosti kriticheskoi tochki v ploskom i osesimmetrichnom potokakh gaza; soveshchanie po teplo-i massoobmenu, g. Minsk, 23-27 ianvaria 1961 g. Minsk, 1961. 15 p. (MIRA 15:2)
(Sublimation (Physical sciences)) (Gas flow)

10.3200
17.4410
26.2181

31246

S/207/61/000/00?/005/015
D237/D303

AUTHOR: Tirskiy, G.A. (Moscow)

TITLE: Surface melting of a solid in the vicinity of the critical point and line in a dissociated air flow with evaporation of the melted layer

PERIODICAL: Zhurnal prikladnoy mekhaniki i tekhnicheskoy fiziki, no. 5, 1961, 39 - 52

TEXT: The author solves a problem for a blunt-nosed body which is either axially symmetric (stagnation point), or plane (stagnation line). He also assumes the presence of the arbitrary but finite number of endothermic fronts within the body, on which absorption of heat may occur. The appearance of such fronts is related to changes in crystalline structure or to rotation of molecules occuring at some critical temperature. Metals and ceramics are examples of materials behaving in the above stated manner. The solution takes into account any relation between thermo-physical parameters and viscosity of melt, and temperature, and it is shown that any

Card 1/3

X

31246
S/207/61/000/005/005/015
D237/D303

Surface melting of a solid in ...

particular case can be reduced to the solution of a finite system. A set of partial differential equations is given and the author shows that for a stationary case it reduces to (2N + 2P + 8) non-linear ordinary differential equations with (N + P + 1) unknown parameters where N = No. of compoents, P = No. of characteristic temperatures, and it is shown that the solution is unique. From solving the solid phase it follows that the separation between the fronts is inversely proportional to the velocity of melting. Temperature distribution in the solid phase is obtained. Solutions for the melted phase and boundary layer are derived and some typical cases are discussed. They are: Disruption of the solid at low temperatures when dissociation of air can be neglected and the boundary layer can be treated as a binary mixture of vapor and air and at high temperatures, when the boundary layer represents a multi-component mixture. The latter is treated as a binary mixture in 1st and as a ternary mixture in 2nd approximation. Also, it is assumed that the surface of the melt is an ideal catalyst for recombination of atoms of air. The equations are given for the case of melting without evaporation and for pure sublimation. There are 10 [illegible]nces: 5 Soviet-bloc and 5 nonSoviet-bloc. The 4 most recent referen-

Card 2/3

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31246

Surface melting of a solid in ... S/207/61/000/005/005/015
D237/D303

ces to the English-language publications read as follows: L. Roberts, Stagnation - point shieldings by melting and vaporization. 1959, NASA TR T - 10; I. Beckwith, Similar solutions for the compressible boundary layer on a yawed cylinder with transpiration cooling, 1958, NACA TN 4345; J.A. Fay and F.R. Riddell, Theory of stagnation point heat transfer in dissociated air, Journ. aero. sci., 1958, vol. 25, No. 2; [illegible] Lighthill, Dynamics of dissociating gas - part I, equilibrium flow. 1957, vol. 2, pt. 1, 1 - 32.

SUBMITTED: May 24, 1961

Card 3/3 X

TIRSKIY, G.A. (Moskva)

Laminar axially symmetrical gas flow around a solid near the critical point. Zhur. vych. mat. i mat. fiz. 1 no.3:481-498 My-Je '61. (MIRA 14:8)

(Gas dynamics)

10.3200
26.2181

30739
S/208/61/001/005/007/007
A060/A126

AUTHOR: Tirskiy, G. A. (Moscow)

TITLE: Sublimation of a blunt body in the vicinity of the critical point in a plane and an axisymmetric flow of a gas mixture

PERIODICAL: Zhurnal vychislitel'noy matematiki i matematicheskoy fiziki, v. 1, no. 5, 1961, 884 - 902

TEXT: The work under review obtains the exact solution (in the form of a uniformly propagated wave) of the problem of equilibrium and nonequilibrium sublimation of a blunt body in the vicinity of the critical point and having an arbitrary relation between the physical properties and the temperature of the body. For Prandtl numbers $\sigma = 0.7$; 1 and Schmidt number Sc = 1, the solution is obtained numerically. By recourse to asymptotic integration the solution is also obtained for arbitrary numbers σ and Sc $\geq$ 0.5. It is shown that, if the accomodation coefficient f > 0.1, the evaporation of the body will then proceed with a precision sufficient for practical purposes according to diffusion kinetics (equilibrium evaporation) with $u_\infty \leq 10^3$ m/sec; for f < 0.1 nonequilibrium evaporation has to be accounted for. The necessary and sufficient condition is derived at which

Card 1/4

30739

S/208/61/001/005/007/007
A060/A126

boiling on the subliming front occurs. In the presence of boiling the sublimation rate and the mass sublimation rate are found in finite form and expressed by the formulae:

$$D = -r_1 \frac{l p_{00}}{\rho_{00}} \sqrt{\frac{M_i}{2\pi R T_{00}}} \left[1 + \frac{c_{p_j}(T_{\omega} - T_{00})}{l(T_{\omega}) + \rho_1 \rho_{10}^{-1} c_* T_{-\infty} [Q(\theta_{10}) - Q(1)]} \frac{M_j}{M_i} \mathrm{Le}^{2/3} \right],$$

$$\rho_{10} D = -l p_{00} \sqrt{\frac{M_i}{2\pi R T_{00}}} \left[1 + \frac{c_{p_j}(T_{\omega} - T_{00})}{l(T_{\omega}) + \rho_1 \rho_{10}^{-1} c_* T_{-\infty} [Q(\theta_{10}) - Q(1)]} \frac{M_j}{M_i} \mathrm{Le}^{2/3} \right]^{-1}.$$

The temperature profile in the body for an arbitrary dependence of the physico-thermal characteristics of the body is found by quadratures. In the general case, the solution of an actual problem reduces to the solution of a system of three finite equations for the determination of concentration, temperature at the evaporation front, and the sublimation rate. Four tables are given with the solutions of the boundary problem for the plane and the axisymmetric cases. These tables, together with the following equations:

30739

Sublimation of a blunt body in...

S/208/61/001/005/007/007
A060/A126

$$-K^{-1}\sigma n a \omega\,(\infty;\,\sigma,\,z_0,\,\alpha) = \frac{h_\infty^* - h_0^*}{\mathscr{L}(T_0)}, \qquad (5.10)$$

$$\frac{h_\infty^* - h_0^*}{\mathscr{L}(T_0)} = \frac{\sigma}{\mathrm{Sc}}\,\frac{\omega\,(\infty;\,\sigma,\,z_0,\,\alpha)}{\omega\,(\infty;\,\mathrm{Sc},\,z_0,\,\alpha)}\,\frac{c_{i0} - c_{i\infty}}{c_{is} - c_{i0}}, \qquad i = 1, \ldots, N-1. \quad (5.11)$$

and

$$\left.\begin{array}{l} \dfrac{p_*}{p_{00}}\,\psi\left(\dfrac{T_0}{T_*}\right)\sum\limits_{k=1}^{N}{}' \dfrac{c_{k0}}{M_k} = \sum\limits_{k=1}^{N'} \dfrac{c_{k0}}{M_k} \qquad \text{или} \\ c_{i0} = \left\{1 + \dfrac{M_j}{M_1}\left[\dfrac{p_{00}}{p_*}\exp\dfrac{l}{R}\left(\dfrac{1}{T_0} - \dfrac{1}{T_*}\right) - 1\right]\right\}^{-1}, \quad p = p_{00} - \dfrac{\rho_\infty \beta^2 x^2}{2}, \quad p \approx p_{00}, \end{array}\right\} (3.8)$$

in the equilibrium case, but

$$\frac{D^*}{r_1} = \sqrt{\frac{\rho_0\mu_0}{\rho_\infty\mu_\infty K}}\,n\varphi(0) = \frac{I\,p(0)}{\rho_\infty\sqrt{\beta\nu_\infty}}\sqrt{\frac{M_1}{2\pi R T_0}}\,(R-1); \qquad (3.10)$$

Card 3/4

Sublimation of a blunt body in...

30739
S/208/61/001/005/007/007
A060/A126

in the nonequilibrium case, where the notation

$$\mathscr{L}(T_0) = l(T_0) + \bar{\rho}_1 \rho_{10}^{-1} \bar{c}_* T_{-\infty} [Q(\theta_{10}) - Q(1)],$$

$$\overline{\rho\mu} = \frac{\rho\mu}{\rho_0\mu_0}, \quad \theta = \frac{T}{T_\infty}, \quad \theta_0 = \frac{T_0}{T_\infty}, \quad \theta_{10} = \frac{T_0}{T_{-\infty}}, \quad \bar{c}_{p\infty} = \frac{c_{p\infty}}{c_{p0}}, \qquad (3.11)$$

$$\sigma_1 = \frac{v_\infty}{\bar{\lambda}_1} \bar{\rho}_1 \bar{c}_*, \quad r_1 = \frac{\rho_\infty}{\rho_{10}}, \quad \rho_{10} = \rho_1(T_0).$$

was used, make it possible to solve the problem in all the cases considered. There are 18 references: 9 Soviet-bloc and 9 non-Soviet-bloc. The references to the 4 most recent English-language publications read as follows: L. Roberts. A theoretical study of stagnation-point ablation. NASA TR R-9, 1959; R. S. Brokaw. Approximate formulas for the viscosity and thermal conductivity of gas mixture. J. Chem. Phys., 1958, 29, no. 2, 391 - 397; E. A. Mason, S. C. Saxena. Approximate formula for the thermal conductivity of gas mixtures. Phys. Fluids, 1958, no. 5, 361 - 369; I. E. Beckwith. Similar solutions for the compressible boundary layer on a yawed cylinder with transpiration cooling. NASA TR R-42, 1959.

SUBMITTED: March 8, 1961

Card 4/4

10.3200

31634

S/207/61/000/006/008/025
A001/A101

AUTHOR: Tirskiy, G.A. (Moscow)

TITLE: Destruction of the front edge of a swept wing in a hypersonic flow

PERIODICAL: Zhurnal prikladnoy mekhaniki i tekhnicheskoy fiziki, no. 6, 1961, 54 - 68

TEXT: At hypersonic flight velocities the equilibrium radiation temperature of the front edge of swept wings may attain values exceeding the melting point of all high-melting metals. If the flight time is short, a partial destruction of the streamlined surface can be allowed. Using this system of "cooling", the rate of destruction should be calculated precisely. The author sets the problem of melting the front edge of a swept wing in the hypersonic flow with allowance for evaporation of the film of the melt. The problem of the melting of the wing placed in a steady gas flow is reduced to solution of the following systems: non-stationary equations of the hypersonic boundary layer in the gas, non-stationary equations of the boundary layer in the film of the melt, and the system of P-1 equations of heat conductivity in a solid (P-1 is the number of characteristic temperatures in the body related to endothermic changes of the crystalline lattice).

Card 1/2

31634

Destruction of the front edge ... S/207/61/000/006/008/025
A001/A101

It is assumed that the melt film is a homogeneous incompressible fluid of constant heat capacity but variable viscosity coefficient, and thermal-physical properties of the body are arbitrary functions of temperature. Two cases are considered in detail: 1) material of the wing is characterized by a definite melting point and a finite number of transition temperatures at which absorption of heat can occur; metals and crystalline modifications of some ceramics are materials of this type; 2) material of the wing does not possess a clear-cut melting point, and temperature dependence of melt viscosity is of an exponential form; various glasses are representatives of this type. Formulae for the rate of melting of the edge are derived for both of these cases by solving the system of equations for the solid phase, liquid phase and boundary layer, neglecting dissociation in the boundary layer. There are 9 references, 7 of which are Soviet-bloc.

SUBMITTED: August 14, 1961

Card 2/2

24.4500

28494
S/040/61/025/002/003/022
D201/D302

AUTHOR: Tirskiy, G.A. (Moscow)

TITLE: Conditions on the surfaces of strong discontinuity in a many-component mixture

PERIODICAL: Prikladnaya matematika i mekhanika, v. 25, no. 2, 1961, 196 - 208

TEXT: The differential equations of an N-component system are

$$\frac{d}{dt}\int_{V_i^*} \rho_i d\tau = \frac{dM_i}{dt} \quad (i = 1, \ldots, N) \qquad (1.1)$$

where V_i is some volume, moving with velocity field v_i, $\rho_i = m_i n_i$ is the density of the i-th component, n_i is the number of moles/unit volume, m_i is the molar mass of the i-th component. Summing

Card 1/7

X

over i, and from the law of conservation of mass gives

$$\frac{d}{dt} \int_{V^*} \rho d\tau = 0 \qquad (1.2)$$

where V* is obtained by summing the V_i^* at the instant of measurement, and moving with velocity

$$v = \sum_{k=1}^{N} c_k v_k \qquad \left(c_i = \frac{\rho_i}{\rho}, \quad \rho = \sum_{k=1}^{N} \rho_k\right).$$

The usual vector notation, the equation of conservation of motion is

$$\frac{d}{dt} \int_{V^*} \rho v d\tau = \int_{S} p_n d\sigma \qquad (1.3)$$

and the equation of conservation of energy is

$$\frac{d}{dt}\int\limits_{V*} \rho\left(e + \frac{v^2}{2}\right)d\tau = \int\limits_S p_n\, v\, d\sigma - \int\limits_S J_q n\, d\sigma \quad \left(e = \sum_{k=1}^{N} c_k e_k\right) \qquad (1.4)$$

where n is the direction of the normal to S, S is the surface bounding V*, e is the potential energy of the system, e_i is the contribution to the total potential energy of the i-th component, and J_q is the density vector of the flow of thermal energy. If Σ is an arbitrary sufficiently-smooth portion of the surface of discontinuity moving with normal velocity D and wholly contained in V (V = V* instantaneously), then for any integral function A(x, y, z, t)

$$\frac{d}{dt}\int\limits_V A\, d\tau = \frac{d}{dt}\int\limits_{V*} A\, d\tau + \int\limits_S A(D - v_n)\, d\sigma. \qquad (1.5)$$

As V contracts into Σ, the left-hand-side of (1.5) converges uniformly to zero, and hence, for time t, the following equations are

Conditions on the surfaces ...

28494
S/040/61/025/002/003/022
D201/D302

obtained:

$$\rho_1 c_{i1}(D - v_{in,1}) = \rho_2 c_{i2}(D - v_{in,2}) \quad (i = 1, \ldots, N) \tag{1.6}$$

$$\rho_1 (D - v_{n1}) = \rho_2 (D - v_{n2}) \tag{1.7}$$

$$\rho_1 (D - v_{n1})\,\mathbf{v}_1 + \mathbf{p}_{n1} = \rho_2 (D - v_{n2})\,\mathbf{v}_2 + \mathbf{p}_{n2} \tag{1.8}$$

$$\rho_1 (D - v_{n1})\left(e_1 + \tfrac{1}{2} v_1^2\right) + (\mathbf{p}_{n1}\mathbf{v}_1) - (\mathbf{J}_q\mathbf{n})_1 = =\rho_2 (D - v_{n2})\left(e_2 + \tfrac{1}{2} v_2^2\right) + (\mathbf{p}_{n2}\mathbf{v}_2) - (\mathbf{J}_q\mathbf{n})_2 \tag{1.9}$$

Finding difference equations for the J_i, and substituting, gives

$$J_i = \frac{n^2}{\rho} \sum_{\substack{k=1 \\ k \neq i}}^{N} m_i m_k D_{ik} [\nabla c_i^* + c_i(\rho v_i - 1) \nabla \ln p] - D_i^T \nabla \ln T \quad (i = 1, \ldots, N) \tag{1.11}$$

$$\mathbf{J}_q = -\lambda \nabla T + \frac{p}{n^2} \sum_{k=1}^{N} \sum_{l=1}^{N} \frac{n_l D_k^T}{m_k \mathcal{D}_{kl}} (\mathbf{V}_k - \mathbf{V}_l) + \sum_{k=1}^{N} h_k \mathbf{J}_k \tag{1.12}$$

$$\left(n = \sum_{k=1}^{N} n_k,\ c_i^* = \frac{n_i}{n} = \frac{m}{m_i} c_i,\ m = \frac{\rho}{n} = \sum_{k=1}^{N} c_k^* m_k = \left(\sum_{k=1}^{N} \frac{c_k}{m_k}\right)^{-1},\ \sum_{k=1}^{N} D_k^T = 0\right)$$

Card 4/7

where c_i^* is the molar concentration, m is the mean molar mass of the mixture, D_{ik} are multicomponent coefficients of diffusion (which may be evaluated in the first approximation by the kinetic energy theory), λ is the coefficient of thermal conductivity, D_i^T the multicomponent coefficients of thermal diffusion, h_i and v_i are the partial specific enthalpy and volume of the i-th component. With Reynold's number tending to infinity, the equations of the mixture become those for a shock-wave in an ideal N-component mixture. The solution in this case is found by approximation methods. The result is obtained in the form

$$\rho(D + u\,\mathrm{tg}\,\beta + w\,\mathrm{tg}\,\gamma - v)(1 - c_i) + J_{iy} = 0$$

$$\rho c_k(D + u\,\mathrm{tg}\,\beta + w\,\mathrm{tg}\,\gamma - v) - J_{ky} = 0 \qquad (k = 1, \ldots, i-1, i+1, \ldots, N) \qquad (1.38)$$

$$\rho(D + u\,\mathrm{tg}\,\beta + w\,\mathrm{tg}\,\gamma - v) = \rho_1(D + u_1\,\mathrm{tg}\,\beta + w_1\,\mathrm{tg}\,\gamma - v_1)$$

Conditions on the surfaces ...

S/040/61/025/002/003/022
D201/D302

$$p = p_1, \quad \mu \frac{\partial u}{\partial y} = \mu_1 \frac{\partial u_1}{\partial y}, \quad \mu \frac{\partial w}{\partial y} = \mu_1 \frac{\partial w_1}{\partial y} \qquad (1.38)$$

$$\rho (D + u \operatorname{tg} \beta + w \operatorname{tg} \gamma - v) l - \frac{p}{n^2} \sum_{k=1}^{N} \sum_{l=1}^{N} \frac{n_l D_k^T}{m_k \mathscr{D}_{kl}} (V_{kv} - V_{lv}) = \lambda_1 \frac{\partial T_1}{\partial y} - \lambda \frac{\partial T}{\partial y} \qquad (1.38)$$

$$u = u_1, \quad w = w_1, \quad T = T_1, \quad c_i = m_i \left(\frac{p}{f(T)} - 1 \right)^{-1} \sum_{k \neq i}^{N} \frac{c_k}{m_k}.$$

where β is the angle in the plane z = 0 between the tangent to some point on the surface of discontinuity and a tangent to the contour of the body at a point with a known x - coordinate, γ is the angle in the plane x = 0 between the tangent to some point on the surface of discontinuity and the tangent to a point on the contour of the body with known z-coordinates,

$$J_{iv} = \frac{n^2}{\rho} \sum_{\substack{k=1 \\ k \neq i}}^{N} m_i m_k D_{ik} \frac{\partial c_i^*}{\partial y} - D_i^T \frac{\partial \ln T}{\partial y} \qquad (1.26)$$

Card 6/7

Conditions on the surface ...

S/0../6./0../...22
B0../B302

Here quantities without an index correspond to the gas ... at the surface of evaporation, index 1 to the liquid phase ... the surface of evaporation, and index . to the components ... The article concludes with 2 worked examples. There are ... and 14 references: 10 Soviet-bloc and 4 non-Soviet-bloc ... rences to the English-language publications read as ... Hirschfelder, C.F. Curtiss, and R.B. Bird. Molecular ... ses and liquids, John Wiley and Sons, Inc., New York, ... Bauer, and M. Zlotnick, Evaporation into a Boundary ... Physics of Fluids, 1958, vol. 1, num. 4.

SUBMITTED: June 22, 1960

Card 7/7

TIRSKIY, G.A. (Moskva)

Heat transfer in the vicinity of the front edge of an infinitely long cylinder inclined to the flow in a dissocaited air flow. Izv.AN SSSR. Otd.tekh.nauk.Mekh.i mashinostr. no.6:125-130 N-D '62. (MIRA 15:12)
(Heat—Radiation and absorption) (Aerodynamics)

TIRSKY, G.A. (Moscow)

"The laminar multicomponent boundary layer on chemically active ablating surface"

Report presented at the 2nd All-Union Congress on Theoretical and Applied Mechanics, Moscow 29 Jan - 5 Feb 64.

APPROVED FOR RELEASE: 07/16/2001 CIA-RDP86-00513R001755810014-9"

ACCESSION NR: AP4043495

S/0293/64/002/004/0570/0594

AUTHOR: Tirskiy, G. A.

TITLE: Analysis of the chemical composition of a laminar, many-component boundary layer on a burning surface

SOURCE: Kosmicheskiye issledovaniya, v. 2, no. 4, 1964, 570-594

TOPIC TAGS: hypersonic ablation, phenol formaldehyde resin ablation, laminar boundary layer, boundary layer, dissociated air flow, ablation, ablation velocity, diffusion coefficient, effective diffusion coefficient, mass transfer, heat transfer

ABSTRACT: An analysis of the chemical composition of the boundary layer on the burning surface of phenol-formaldehyde plastics in a dissociated air flow is carried out. The effective diffusion coefficients and the corresponding mass transfer coefficients in a many-component (15—20) gas mixture are calculated. A theorem of closeness of the effective diffusion coefficients in the entire boundary layer thickness for all components which are nearly equal

Card 1/3

ACCESSION NR: AP4043495

in molecular height and gas-kinetic parameters and which satisfy the boundary conditions $c_i(\infty)=0$ or $c_i(0)=0$ is proved for all self-similar motion in a many-component frozen boundary layer. It is shown that for phenol-formaldehyde resins it is generally necessary to introduce at least five substantially different effective diffusion coefficients since the mass transfer coefficients depend on boundary conditions and in particular on the degree of air dissociation on the outer edge of the boundary layer. The introduction of five effective diffusion coefficients makes it possible to describe practically and accurately the diffusion processes, ablation velocity, temperature, and composition of the combustion front. A formula is derived for determining the air composition on an ideal catalytic nonablating wall with respect to the degree of dissociation on the outer edge of a boundary layer. Calculations by this formula agree well with the numerical solution. For a certain range of external parameter variation, a formula for combustion velocity of plastics without formation of a liquid film is obtained with respect to the degree of dissociation and to the chemical composition of the components of the initial material. By using the concept of effective diffusion

ACCESSION NR: AP4043495

coefficients in the ablation process, similar analyses can be carried out for such other plastics as teflon, nylon, and organic glass. Orig. art. has: 4 tables and 68 formulas.

ASSOCIATION: None

SUBMITTED: 08May64 ATD PRESS: 3088 ENCL: 00

SUB CODE: ME, MT NO REF SOV: 013 OTHER: 009

Card 3/3

TIRSKIY, G.A.

Determination of the effective diffusion coefficients in a laminar multicomponent boundary layer. Dokl. AN SSSR 155 no.6:1278-1281 Ap '64. (MIRA 17:4)

1. Moskovskiy fiziko-tekhnicheskiy institut. Predstavleno akademikom L.I.Sedovym.

ACCESSION NR: AP4041137 S/0020/64/156/004/0756/0759

AUTHOR: Tirskiy, G. A.; Sedov, L. I.

TITLE: Theory of the laminar multi-component boundary layer on chemically active surfaces

SOURCE: AN SSSR. Doklady*, v. 156, no. 4, 1964, 756-759

TOPIC TAGS: multi component boundary layer, chemically active surface, hydromechanics, surface burning, stationary gas flow

ABSTRACT: The author solves equations for the laminar multicomponent boundary layer in the vicinity of the critical point (or line) on a burning surface of a body of a complex composition, by using the effective diffusion coefficients introduced in an earlier work (DAN 155, no. 6, 1964). The solution must give information about concentration, temperature at the burning front, and the velocity of this mass transfer. Even the simplest case (equiponderate burning of graphite in dissociated air) cannot be described by a binary boundary layer, as the effective diffusion coefficient for the reaction products CO and CN change up to 60% depending on the degree of air dissociation. For complex materials, at least 5

Card 1/2

ACCESSION NR: AP4041137

different diffusion coefficients are needed for the various compounds formed. Orig. art. has: 22 equations.

ASSOCIATION: Moskovskiy fiziko-tekhnicheskiy institut (Moscow Physico-Technical Institute)

SUBMITTED: 08Mar64

ENCL: 00

SUB CODE: ME

NO REF SOV: 005

OTHER: 001

Card 2/2

L 13811-65 EWT(1)/EWP(m)/EWT(m)/EPF(c)/EPF(n)-2/EPR/EWP(t)/
EWP(b)/EWA(1) Pd-1/Pr-4/Ps-4

ACCESSION NR: AP4047316

S/0020/64/158/004/0798/0801

AUTHOR: Reznikov, B. I.; Tirskiy, G. A.

TITLE: Generalized analogy between mass-transfer coefficients in a laminar, multicomponent boundary layer with an arbitrary pressure gradient

B

SOURCE: AN SSSR. Doklady*, v. 158, no. 4, 1964, 798-801

TOPIC TAGS: mass transfer, heat transfer, laminar boundary layer, boundary layer, effective diffusion coefficient, Fick law, diffusion equation

ABSTRACT: Similarity of the mass-transfer coefficients is generalized for the case of a multicomponent gas flow in a boundary layer with an arbitrary pressure gradient and arbitrary distribution of mass injection along the surface. By using the concept of effective diffusion coefficients introduced in the author's previous work (Doklady* AN SSSR, v. 155, no. 6, 1964), the diffusion equations of the components are established in ordinary form but with their variable diffusion coefficients, derived by using the Fick law. The equations are

Card 1/2

L 13811-65

ACCESSION NR: AP4047316

solved by the method of asymptotic integration with $S_i \to \infty$ (S_i - Schmidt number) and with moderate injection along the surface of the body, called the method of steepest descent by D. Meksyn. It is shown that the relations between mass-transfer coefficients retain the structure established for self-similar solutions, though the values contained depend now on the longitudinal coordinate. The dependence upon body shape is weak. In particular, the generalized similarity of mass- and heat-transfer coefficients is obtained by the same method when the mixture consists of gases with nearly similar heat capacities or when one component has a very different heat capacity from the others. Orig. art. has: 18 formulas.

ASSOCIATION: none

SUBMITTED: 03Jun64 ATD PRESS: 3131 ENCL: 00

SUB CODE: ME NO REF SOV: 002 OTHER: 001

Card 2/2

L 39291-65 EWT(1)/EWP(m)/EWA(d)/FCS(k)/EWA(1) Pd-1
ACCESSION NR: AP5009542 UR/0207/65/000/001/0045/0056

27
B

AUTHOR: Tirskiy, G. A. (Moscow)

TITLE: Determining heat fluxes at a double-curvature stagnation point of a body in a dissociated gas flow of arbitrary chemical composition

SOURCE: Prikladnoy mekhaniki i tekhnicheskoy fiziki, no. 1, 1965, 45-56

TOPIC TAGS: dissociated gas flow, heat flux, boundary layer, compressible flow, gas injection, effective diffusion coefficient, diffusion, energy transfer, critical point, dissociation

ABSTRACT: The author presents the results of numerical solutions of equations which describe a compressible, homogeneous boundary layer with variable physical properties near the stagnation point, of different principal curvatures, when a gas with the same properties as those of the free flow is injected into the boundary layer. The results of numerical solutions are approximated for a heat flux in the form of a formula which depends on the variability of the product of the viscosity and density ($\mu\rho$) across the layer and on the ratio of the principal radii of curvature. The use of the concepts of effective diffusion coefficients in a many-component boundary layer, introduced earlier by the author (Doklady AN SSSR,

Card 1/3

L 39291-65
ACCESSION NR: AP5009542

v. 155, 1964, p. 1278), and of the generalized analogy between heat transfer and mass transfer in the presence of gas injection, also utilization of the numerical solutions obtained, makes it possible to obtain finite formulas for heat fluxes in the flow of a dissociated gas of arbitrary chemical composition under the basic assumption that all recombination reactions take place on the wall. As illustrative examples, formulas are derived for thermal fluxes to the wall of dissociating air, which is regarded as a five-component mixture of O, N, NO, O_2, and N_2, and of a dissociating mixture of carbon dioxide and molecular nitrogen of arbitrary composition, regarded as an eleven-component gas mixture of O, N, C, NO, C_2, O_2, N_2, CO, CN, C_3, CO_2. Analysis of the solutions obtained shows that when calculating the heat flux, replacing a many-component mixture by the effective binary mixture with one diffusion coefficient is possible only when the mixture can be divided in two groups of components with equal (or closely similar) diffusion properties; while the concentration of one of the group on the wall should equal 0, the diffusion fluxes of the other group can be expressed by diffusion fluxes of the first group through the use of the laws of mass conservation of the chemical components. In this case, a binary diffusion coefficient D(A, M), where A is related to one group of components and M to the other, will figure as the unique effective diffusion coefficient. It is concluded that the specific heat flux for flight in carbon dioxide will always be larger than that for flight in air at every point of body surface. Orig. art. has: 2 figures, 52 formulas, and 2 tables. [AB]

Card 2/3

L 55965-65

ACCESSION NR: AP4034028 UR/0020/64/155/006/1278/1281

AUTHOR: Tirskiy, G. A.

TITLE: Determining the effective coefficients of diffusion in a laminar multicomponent boundary layer

SOURCE: AN SSSR. Doklady, v. 155, no. 6, 1964, 1278-1281

TOPIC TAGS: boundary layer, boundary layer flow, laminar flow, diffusion coefficient

ABSTRACT: In multicomponent gas mixtures the diffusion rate vectors $V_i = v_i - v$ are related to concentration gradients by N-1 independent Stephan-Maxwell equations of the form

$$\nabla c_i = \sum_{j=1}^{N} \frac{c_i x_j}{D_{ij}} (V_j - V_i) - \sum_{k=1}^{N} c_k \sum_{j=1}^{N} \frac{c_k x_j}{D_{kj}} (V_j - V_k) \quad (i = 1, \ldots, N),$$

$$c_i = \frac{m_i}{m} x_i, \quad m^{-1} = \sum_{k=1}^{N} \frac{c_k}{m_k}, \quad J_i = \rho_i (v_i - v) = \rho_i V_i,$$

Card 1/4

L 55965-65
ACCESSION NR: AP4034028

where x_i is the molecular concentration, m_i is the molecular weight of the i^{th} component, m is the mean molecular weight of the mixture, D_{ij} is the coefficient of binary diffusion, J_i is the vector of mass diffusion flow, and N is the number of components. The diffusion vector J_i may be related to the diffusion coefficients by the equation

$$J_i = \rho_i (v_i - v) = \rho_i V_i = -\rho D_i \frac{\partial c_i}{\partial y} \quad (i = 1, \ldots, N).$$

where the effective diffusion coefficients D_i are determined from the formula

$$\frac{1}{D_i} = \sum_{j=1}^{N} \frac{x_j}{D_{ij}} \frac{v_j - v_i}{v_i - v} + \sum_{k=1}^{N} c_k \sum_{j=1}^{N} \frac{x_j}{D_{kj}} \frac{v_j - v_k}{v_i - v} \quad (i = 1, \ldots, N).$$

This method of computing the effective diffusion coefficients is demonstrated for the case of a mixture in which all binary diffusion coefficients can be divided into three groups $D_{ij} = D$ $(i, j = O_2, N_2, NO, CO, CN)$, $D_{i\alpha}$ $(\alpha = O, N)$. The effective diffusion coefficients are then computed as

Card 2/4

L 55965-65
ACCESSION NR: AP4034028

$$\frac{1}{D_O} = \frac{1}{D_{la}} + B\left(x_N - \frac{m}{m_a}\frac{c_N V_N}{c_O V_O} c_O\right), \quad \frac{1}{D_N} = \frac{1}{D_{la}} + B\left(x_O - \frac{m}{m_a}\frac{c_O V_O}{c_N V_N} c_N\right),$$

$$\frac{1}{D_l} = \frac{1 - x_O - x_N}{D_{ll}} + \frac{x_O + x_N}{D_{la}} + \left(\frac{1}{D_{ll}} - \frac{1}{D_{la}}\right)\frac{m}{m_l}\frac{c_O V_O + c_N V_N}{c_l V_l} c_l \; (l = O_2, NO, CO, CN),$$

$$\frac{m}{m_l} = \frac{1 - x_O - x_N}{1 - c_O - c_N}, \quad B = \frac{1}{D_{aa}} - \frac{1}{D_{la}}, \quad \frac{1}{D_{ll}} - \frac{1}{D_{la}} = \frac{0,285}{D_{ll}} = \frac{0,400}{D_{la}}.$$

The author also derives the equations

$$\left(\frac{c_l V_l}{c_j V_j}\right)_0 = \left[\frac{\rho D_l c_l'(0)}{\rho D_j c_j'(0)}\right]_0 = \frac{c_{le} - c_{l0}}{c_{je} - c_{j0}}\left(\frac{D_{l0}}{D_{j0}}\right)^{0,6}.$$

for diffusion mass flow at the boundary. It is demonstrated that the effective coefficients of diffusion at the wall are equal to the corresponding binary coefficients multiplied by known functions from the degree of dissociation. A concrete example is given, and the proposition is proved by demonstration that

Card 3/4

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ACCESSION NR: AP4034028

the generalized Schmidt numbers S_i are positive throughout the thickness of the boundary layer. Orig. art. has: 16 equations and 1 figure.

ASSOCIATION: Moskovskiy fiziko-tekhnicheskiy institut (Moscow Physico-Technical Institute)

SUBMITTED: 06Mar64 ENCL: 00 SUB CODE: ME

NO REF SOV: 002 OTHER: 001

Card 4/4

TIRSKIY, G.A. (Moskva)

Determination of heat flows near the critical point of double curvature for a body in a flow of a dissociating gas of arbitrary chemical composition. PMTF no.1:45-56 Ja-F '65.

(MIRA 18:8)

IVANOV, Georgiy Ivanovich; TIRSKIY, I.T., red.

[People of the virgin snow]Liudi snezhnoi tseliny. IAkutsk, IAkutskoe knizhnoe izd-vo, 1963. 40 p.
(MIRA 17:5)

[illegible]HENKO, V.P., kand. tekhn. nauk; SOLODOV, A.P., inzh.; TIRUNARAYANAN, M.A.

Study of heat emission during the condensation of water vapor in vertical pipes. Trudy MEI no.63:97-106 '65.

(MIRA 18:12)

SAVII, Gh.; TRUSCULESCU, M.; BAGIU, L.; TACHE, Gh.; TIRZIU, V.

Study of the connection between the surface state and the wear in the case of sliding friction. Bul St si Tehn Tim 9 no.2:453-461 Jl-D '64.

ISTATKOV, St., inzh., kandidat na tekhn. nauki; TISA, Ishtv.
[Tisza, Istv.], inzh., kandidat na tekhn. nauki (Ungariia);
KOVAL'OV, I. [Kovalev, I.], inzh. (SSSR)

Methods for modeling and computing elastic metallic shields
in the ore and mineral mine pits. Min delo 17 no.11:23-28 '62.

1. Minno-geolozhki institut (for Istatkov).

TISAREK, B.

(30)

Praque, [illegible]
Copyright [illegible]

1. "[illegible] Research in [illegible]," [illegible] pp 1-7.

2. "Immunological [illegible] Arthritis. [illegible] Rheumatoid [illegible] Hlinsko [illegible] director (Prague); pp 3-13 [English summary].

3. "Immunological [illegible] arthritis. [illegible] Rheumatoid [illegible] of Antigen," [illegible] Institute as [illegible]

4. "[illegible] Gold and Hormones," [illegible] [English abstract].

5. "[illegible] (Ceske [illegible]) [illegible] physician [illegible]

6. "[illegible] Institute for [illegible] K. [illegible], Professor [illegible] [English summary].

7. "[illegible] Alexander [illegible] University [illegible] Professor [illegible] [English summary].

8. "Treatment of [illegible] Charles University [illegible] Medicine [illegible] director [illegible] hospital [illegible] [English summary].

9. "Some Notions on the [illegible] in [illegible] and [illegible] in East Germany," [illegible] (Vodni Zdroje),

245

— 1/2 —

TISCHLER, Marton

International exhibition of agricultural machinery at the Paris Salon. Jarmu mezo gep 8 no.11:433-438 N '61.

1. Koho- es Gepipari Minisztérium Mezogepfejlesztesi Intezete.

TISCHLER, Marton, csoportvezeto [illegible]

Testing the threshability of [illegible] grains. [illegible] 266-269 Jl '64.

1. Long-Range Development Department, Ministry of [illegible] and Machine Industry, Budapest.

JACINA, J.; TISCHLER, V.

Relation of infectious diseases and tuberculosis in children.
Cesk.pediat. 11 no.2-3:127-132 Mar 56.
(TUBERCULOSIS, compl.
infect. dis. in child, statist.)
(COMMUNICABLE DISEASES, compl.
tuberc. in child., statist.)

MIKHALEVA, V.Ya.; KOLESINSKAYA, N.I.; SHVETS, K.I.; TIRSKIKH, V.A.

Determination of the immunogenic properties of serially produced bivalent vaccines on the basis of minimal immunizing doses. Izv. Irk.gos.nauch.-issl.protivochum.inst. 20:207-211 '59. (MIRA 13:7)

(PLAGUE) (VACCINES)

MIKHALEVA, V.Ya.; KOLESINSKAYA, N.I.; SHVETS, K.I.; TIRSKIKH, V.A.

Immunogenic properties of bivalent vaccine in relation to the dissociation of standard vaccines of plague strains. Izv.Irk. gos.nauch.-issl.protivochum.inst. 20:213-217 '59.

(MIRA 13:7)

(PLAGUE) (VACCINES)

MIKHALEVA, V.Ya.; KOLESINSKAYA, N.I.; SHVETS, K.I.; TIRSKIKH, V.A.

Determining the immunogenic properties of mass-produced bivalent antiplague vaccines on the basis of minimum immunizing doses. Tez. i dokl. konf. Irk.gos.nauch.-issl.protivochum. inst.no.2:32-33 '57.
(PLAGUE) (VACCINES) (MIRA 11:3)

MITIN, S.V.; TIRSKIKH, V.A.

Effect of onion and garlic phytonicides on the plague bacillus; preliminary report. Izv. Irk.gos.protivochum.inst. 9:53-62 '51.
(PHYTONCIDES) (MIRA 10:12)
(PASTEURELLA PESTIS)

TIRSKIY, I. A.

"Melting of a body in the region of the critical point in a flat and in an axially symmetrical gas flow."

Report presented at the 1st All-Union Conference on Heat- and Mass- Exchange, Minsk, BSSR, 5-9 June 1961

ZHAK, D.; P.RZBANURT, T.

Calculating Machines

State of mechanization in accounting and calculating, Vest. stat, No. 2, 1952.

~~Monthly List of~~ Russian Accessions, Library of Congress, July 1952. Unclassified

TISA, I.

Ways to increase the efficiency of bauxite deposit mining in the Northern Urals. Izv. vys. ucheb. zav.; tsvet. met. 3 no. 6:9-12 '60. (MIRA 14:1)

1. Krasnoyarskiy institut tsvetnykh metallov. Kafedra razrabotki rudnykh mestorozhdeniy.

(Ural Mountains--Bauxite) (Mining engineering)

TISA, I.

Design and modeling of flexible metal fences for mine workings as applicable to new mining systems with roof bolting and ore extraction on strike. Izv. vys. ucheb. zav.; tsvet. met. 4 no.4:16-23 '61. (MIRA 14:8)

1. Krasnoyarskiy institut tsvetnykh metallov, kafedra razrabotki rudnykh i rossypnykh mestorozhdeniy.
(Mine roof bolting)
(Mining engineering--Electromechanical analogies)

TISA, ISHTVAN

Cand Tech Sci - (diss) "Means for increasing the efficiency of systems of working bauxite deposits of the Hungarian People's Republic." Moscow, 1961. 12 pp with diagrams; (Ministry of Higher and Secondary Specialist Education RSFSR, Krasnoyarsk Inst of Non-ferrous Metals imeni M. I. Kalinin); 200 copies; price not given; (KL, 6-61 sup, 226)

TISAJ, T.

Activities of trade-unions in enterprises after the liberation. p. 410.

ENERGIJA. (ZAjednica elektroprivrednih poduzeca Hrvatske i Institut za elektroprivredu u Zagrebu) Zagreb, Yugoslavia. Vol. 7, no. 10, 1958.

Monthly List of East European Accessions (EEAI) LC, Vol. 8, no. 6, June 1959.

Uncl.

MATHEOVA, E.; JACINA, J.; TISCHLER, V.; MACEJKO, G.

Use of a Na-sensitive glass electrode in potentiometric determination of sodium in biological material. Bratisl. lek. listy 44 no.6:353-357 30 S '64.

1. Katedra starostlivosti o dieta Lek. fak. University P.J. Safarika v Kosiciach, (veduci prof. MUDr. F. Demant).

KAZANTSEV, V.F.; TISENBAUM Yu.L.

Movement of a suspension of abrasive particles under ultrasonic treatment. Akust. zhur. 7 no.4:493-495 '61. (MIRA 14:10)

1. Akusticheskiy institut AN SSSR, Moskva.
(Suspensions(Chemistry))
(Ultrasonics)

KUZNETSOV, V.I.; TISHAKOV, S.B.

Fastening of nozzles for the supplying of atomized liquids by means of permanent magnets. Stan.i instr. 32 no.11:38 N '61. (MIRA 14:10)

(Machine-shop practice)

D'YAKOV, O.P. (Moskva); TISCHENKO, N.M. (Moskva); UDALOV, N.P. (Moskva)

Time relay using a thermisor and a magnetic relay. Avtom. i telem. 22 no.5:648-653 My '61. (MIRA 14:6)
(Electric relays) (Delay networks)

10.8100

Z/030/62/000/011/001/003
E160/E435

AUTHORS: Hajda, J., Doctor, Tischler, J. Engineer

TITLE: Photoelastic interferometer

PERIODICAL: Jemná mechanika a optika, no.11, 1962, 334-338

TEXT: A detailed optical and mechanical specification is given of the interferometer built, according to the description published by D. Post by the Ústav teorie merania i meriacich prístrojov ČSAV (Institute on the Theory of Measurements and Measuring instruments, Czechoslovak AS). Drawings of some important parts as well as examples of recordings obtained on two loaded models are included. The contrast of the interference fringes on the photographic recordings was adequate. The method is not affected by the thickness of the model although, common to all interferometers, it must have optically homogeneous properties. Accuracy of determining the sum of the principal stresses by this method was also investigated. There are 12 figures.

ASSOCIATION: ÚTMMP-ČSAV Bratislava (ÚTMMP-Czechoslovak AS Bratislava)

SUBMITTED: August 29, 1962

Card 1/1

√B

PAVKOVCEKOVA, O.; JACINA, J.; TISCHLER, V.

Kidney function tests in children with Henoch-Schoenlein purpura.
Cesk. pediat. 17 no.9:775-779 S '62.

1. Detska klinika Fakultnej nemocnice v Kosiciach, prednosta prof.
dr. F. Demant.

(PURPURA) (KIDNEY FUNCTION TESTS)

[illegible], A.S.; TISHEL'[illegible], A.P.

Microcrystalloscopic reaction for the zinc ion with the aid of ethyl-p-toluenesulfonate of 2-methyl-4,5-benzobenzothiazole. Ukr. khim. zhur. 27 no. 1:98-101 '61. (MIRA 14:3)

1. Khar'kovskiy politekhnicheskiy institut im. V.I. Lenina.
(Zinc--Analysis)

KAZANTSEV, V.F.; TISENBAUM, Yu.L.

Study of the temperature dependence of the velocity of ultrasonic treatment. Akust.zhur. 7 no.2:260-262 '61. (MIRA 14:6)

1. Akusticheskiy institut AN SSSR, Moskva.
(Ultrasonic waves—Industrial applications)

S/046/61/007/004/011/014
B104/B102

AUTHORS: Kazantsev, V. F., Tisenbaum, Yu. L.

TITLE: Character of motion of an abrasive suspension in ultrasonic treatment

PERIODICAL: Akusticheskiy zhurnal, v. 7, no. 4, 1961, 493-495

TEXT: The transport of abrasive material has been investigated experimentally in a working gap for an abrasive suspension. Fig. 1 shows a diagram of the test layout. Tools of different types were used to obtain openings 2 in a glass plate 1. While working on the glass plate it was possible to observe the motion of abrasive particles in the opening. A high-speed camera 3 was located perpendicular to the plane of the tool. The СКС-1 (SKS-1) camera was operated with 1000-5500 pictures per second, and the movie camera "Konvas" with 24 pictures per second. The pictures were enlarged twice their size. Three СВДШ 250 (SVDSh-250) mercury lamps, 4, arranged under an angle of 120°, were used as light sources. The experiments were made with an ultrasonic machine 4770, the vibration amplitude of the tool measured was 30μ, and its frequency 18 kc/sec.

Card 1/3

Boron carbide no.80 was employed. The motion pictures showed that there was no intermixture of abrasive particles in the working gap. The random motion of particles was of very high velocity. In several cases, the coarse particles were moving slowly along the tool. Cavitation and gas bubbles showed a strong effect on the particle motion in the working gap. The random motion of bubbles occurred at a higher velocity than that of the particles. Steady microflows formed around the bubbles, and collected the fine particles. These fine particles moved at the same velocity as the bubbles to the end of the tool. The motion of coarse particles (~1mm/sec) is related to elastic vibrations of the tool. This does not affect the processing rate. Even a slowing-down of the processing rate by coarse particles has been established (Blank D., Pahlitzsch. Fortschritte beim Stosslaeppen mit Ultraschallfrequenz. Werkstattstechnik, 1960, 50, 592-599). There are 1 figure and 5 references: 1 Soviet and 4 non-Soviet. The three references to English-language publications read as follows: E. A. Neppiras. Report on Ultrasonic machining. Metalworking production. 1956, 100, 28, 1339; E. J. Jackson, W. L. Nyborg. Microscopic eddying near a vibrating ultrasonic tool tip. J. Appl. Phys., 1959, 30, 949 - 950; E. J. Jackson, W. L. Nyborg. Sonically induced microstreaming

Character of motion of an abrasive ... S/046/61/007/004/011/014
B104/B102

near a plane boundary. J. Acoust. Soc. America, 1959, 32, 10, 1243-1250; 11, 1387-1392.

ASSOCIATION: Akusticheskiy institut AN SSSR Moskva (Acoustics Institute AS USSR, Moscow)

SUBMITTED: July 14, 1961

Card 3/3

TISENKO, Nikolay Gavrilovich, kand. tekhn. nauk; TYUMENEVA, S.T., inzh., red.; FREGER, D.P., red. izd-va; GVIRTS, V.L., tekhn. red.

[Self compensating wire strain gauges for general use] Samokompensirovannye provolochnye tenzodatchiki obshchego naznacheniia. Leningrad, 1961. 43 p. (Leningradskii Dom nauchno-tekhnicheskoi propagandy. Obmen peredovym opytom. Seriia: Kontrol' kachestva produktsii, no.3) (MIRA 14:7)

(Strain gauges)

TISHANINOVA, L.V.

Investigating the excitability and reactivity of the cerebral cortex of a rabbit during the formation of a conditioned defense reflex. Trudy Inst. vys. nerv. deiat. Ser. fiziol. 6:232-243 '61. (MIRA 14:12)

1. Iz Laboratorii elektrofiziologii uslovnykh refleksov, zav. - M.N.Livanov.

(CONDITIONED RESPONSE)

TBC

B-1-5

SMELTING OF PIG IRON FROM TITANIUM MAGNETITES. J. R. Tischbein (Sovet. Met., 1934, 6, 356--371).--Blast-furnace runs were made with (a) conc. agglomerate containing Fe 60, TiO_2 3.5, V_2O_5 0.43%; (b) untreated Kusin ore (Fe 52, TiO_2 13, V_2O_5 0.73%); (c) untreated Kusin ore mixed with "salted" coke (7% NaCl). (a) and (b) gave a high recovery of V and low S in the pig Fe. (c) gave a very liquid slag, poor recovery of V, and high S. Cl had a destructive effect on the furnace linings and fittings. Ch. Abs. (e)

ASM-SLA METALLURGICAL LITERATURE CLASSIFICATION

BC

B-I-4

1ST AND 2ND ORDERS

PROCESSES AND PROPERTIES INDEX

Effect of enrichment of air with oxygen on the temperature gradient of blast furnaces. J. R. [illegible] (Bull. Acad. Sci. U.R.S.S., 1939, Cl. Sci. Tech., No. 11, 65—80).—Considerable fuel economy is achieved by using air containing 30% of O_2.
R. T.

ASM-SLA METALLURGICAL LITERATURE CLASSIFICATION

MATERIALS INDEX

AUTHOR INDEX

Wireless Engineer
July, 1954
Aerials and Transmission Lines

621.372.8 1991

Transmission and Matching Theory of Homogeneously Guided Waves.—F. J. Tischer. (*Arch. elekt. Übertragung*, Jan. & Feb. 1954, Vol 8, Nos. 1 & 2, pp. 8–14 & 75–84.) Mathematical expressions for propagation in waveguide systems are derived directly from Maxwell's equations. The orthogonal curvilinear coordinate system is used. Particular cases considered include propagation in cylindrical systems and the effects of terminations, inhomogeneities, discontinuities and coupling.

1ST AND 2ND ORDERS

PROCESSES AND PROPERTIES INDEX

B-II-1

BC

Hydrolysis of chlorobenzene in the vapour phase. D. Tischtschenko, R. Gutner, S. Farrman, and M. Schtschigelskaja (J. Appl. Chem. Russ., 1935, 8, 685—694).—The optimum temp. of hydrolysis of PhCl (I) by H_2O in presence of Ca, Sr, Ba, Mg, or Cu chlorides is 550—600°; pyrolysis of the resulting PhOH is least when the catalyst consists of SiO_2 gel 90, $MgCl_2$ 10%, $CuCl_2$ traces, and the reaction mixture contains 0·7 g. of H_2O per g. of (I), when the yields are: PhOH 47, unaltered (I) 30·7, HCl (as 24% acid) 60·6% of theory. The aq. HCl obtained contains 3—4% of PhOH, from which it is largely separable by fractional distillation. R. T.

ASM-SLA METALLURGICAL LITERATURE CLASSIFICATION

PROCESSES AND PROPERTIES INDEX

BC

A-3

Aliphatic chloro-derivatives. X. Action of chlorine on Δα- and Δβ-pentenes. D. Tischtschenko and N. [illegible] (J. Gen. Chem. Russ., 1937, 7, 1246—1248).—Δβ-Pentene and Cl_2 yield a mixture of diastereoisomeric βγ-dichloropentanes, b.p. 140—141° and 143—144°; Δα-pentene similarly gives αβ-dichloropentane, b.p. 146·4—148·8°, with about 1% of a monochloropentene in both cases. The presence of substances binding HCl ($CaCO_3$, CaO, KOH) does not affect the result. R. T.

ASM-SLA METALLURGICAL LITERATURE CLASSIFICATION

1ST AND 2ND ORDERS

PROCESSES AND PROPERTIES INDEX

BC

A-3

Aliphatic chloro-compounds. XV. Chlorination of isobutylene. I. DIAKONOV and D. TISCHCHENKO (J. Gen. Chem. Russ., 1939, 9, 1258—1264).—$CMe_2:CH_2$ and Cl_2 combine to give $Bu^{\gamma}Cl$, isobutenyl chloride (I), and a mixture of 40% of $CHCl:CMe\cdot CH_2Cl$ and 60% of $CH_2:C(CH_2Cl)_2$, identified by ozonisation to chloro- and dichloro-acetone respectively. A similar mixture of unsaturated Cl_2-compounds is produced by chlorination of (I) in presence of Na_2CO_3. The production of these Cl_2-compounds is due to an abnormal Lvov-Kondakov reaction and is less marked than with $CMe_2:CHMe$, in which steric hindrance plays a greater part in preventing the normal addition of Cl_2 to the double linking, in agreement with the theoretical considerations already put forward. G. A. R. K.

ASB-SLA METALLURGICAL LITERATURE CLASSIFICATION